ON THE ANATOMY OF *EPHIPPODONTA MACDOUGALLI*, TATE.

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PLATE II.

Owing to the kindness of Mr. E. R. Sykes, I have had placed at my disposal a number of specimens of a very interesting lamellibranch, viz. :—*Ephippodonta MacDougalli*, Tate.

In his original description[1] the founder of this genus enumerates briefly the leading external characters of the animal and its shell, but makes no attempt to deal with its detailed anatomy, and further, as one or two points which he describes in its external features are inaccurate, I have thought it worth while to place on record a more detailed account based on the careful dissection of two specimens and on two complete series of transverse sections of decalcified specimens examined microscopically. The largest specimen measured 11mm. long, the smallest 7mm.

The Shell presents one or two interesting features which have not yet been described. One of the most striking may be noticed on holding the valves up to the light, when it will be seen that their structure is like a lattice-work, being made up of a series of strong radiating costæ and of slighter circumferential bands, the interspaces being extremely thin and transparent, so much so that in decalcified sections the shell seems in places to be almost wanting.[2] The numerous series of conspicuous spines are attached to the costæ.

Vertical sections of the dried shell show that it is entirely devoid of periostracum, and also of any prismatic layer, unless the radiating lines (Fig. 18, *f. l.*) observable in the spines are to be so interpreted; these lines have, however, much more the appearance of radiating tubules, especially in the thinner decalcified section, and such I take them to be; they seem moreover to communicate with a central cavity in each spine. The main mass of the shell appears to be made up of lamellæ deposited parallel to the surface of the shell and apparently representing the nacreous layer (Fig. 18, *n. l.*).

The absence of the periostracum is another point of resemblance, in addition to those enumerated by Tate, between this form and *Scintilla*.[3]

The organic basis of the shell is very slight, and in section the shell has the appearance of a series of spines united by a mere strand of conchiolin.

An internal ligament is present as in *Galeomma*.

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[1] Trans. Roy. Soc. S. Aust. xi. 1889, p. 63 and xiv. p. 267.

[2] It is interesting to note that in *Scintilla* the shell may be finely perforated.

[3] Deshayes, Proc. Zool. Soc. 1855. p. 171.

The Mantle and muscular system.— Ventrally the mantle folds are distinct from one another for about three-quarters of their length, in the posterior fourth they are fused together (Fig. 1, *m.''*) but separate again at the extreme posterior end of the body. In this way two openings are left between the folds, a small posterior one corresponding to the exhalent siphonal (anal) aperture (Figs. 2, 5, 6, 16, *sp.*) and a large antero-ventral one representing the pedal, byssal and branchial openings (branchio-pedal aperture).

The anal aperture appears at first sight to be devoid of a siphon, but microscopic examination of transverse sections (Fig. 16, *sp.*) shows that there is in reality a small rudimentary one present, so small that it is not in all probability protrusible beyond the mantle edge. Its presence is, however, of interest, as we find a single but small siphon present in *Galeomma*.

The margins of the mantle are enormously thickened and muscular and the extreme edge is beset with sensory papillæ, the inner border is produced inwardly as a strong muscular shelf, which is probably capable of great contraction and with the foot closes the gaping aperture between the valves in the contracted condition (Figs. 8 to 10).

The pallial muscle is well developed, and presents an unbroken line extending in an arc from the anterior to the posterior adductor muscle. The adductor muscles (Fig. 5, *pa. ad.*) are small and incapable of closing the valves; the anterior is slightly the largest; in both a dorsal portion is slightly differentiated from the main mass of the muscle.

The pedal retractors (Figs. 2 and 5, *ar. pr.*) are well developed, the posterior being the largest. A large protractor pedis (*pp.*) is also present.

Perhaps the most striking feature in connection with the mantle is seen in its relation to the shell. Careful microscopic examination of transverse sections of decalcified specimens reveals the fact that a thin layer of the mantle is reflected over the outer sides of the valves, and completely covering them comes into contact and fuses with the body-wall between the two valves in the mid-dorsal line (Figs. 8 to 16, *m'*). Thus each valve is completely enclosed in a fold of mantle, or in other words the shell has become an internal one.

The fold of the mantle covering the shell consists of a double layer of cells with a thin layer of connective tissue between them. The outer layer is further produced into numerous club-shaped papillæ, which are in all probability sensory. In some few places the calcified spines appear to pierce and project through this thin covering (Fig. 10). This may very possibly be due to the somewhat rough handling which the specimen has undergone, and, in some cases, to the explosive nature of the decalcifying process, for I find no definite region where the shell is uncovered.

The internal character of the shell is a very interesting feature, since there is only one other Lamellibranch hitherto recorded in which this is the case, viz. :—*Chlamydoconcha*, Dall.[1] Dr. Dall states

[1] Science, iv. 1884, p. 50–51.

that "Nothing of the sort or in the least approaching it has ever been described"; but this statement is not quite accurate, since it has long been known both in *Galeomma*[1] and *Scintilla*[2] that the valves were to a large extent covered by a reflection of the mantle. Both genera further resemble *Ephippodonta* in the fact that their reflected mantle is beset with a series of papillæ.

This reflected layer of the mantle is, I believe, concerned in the thickening of the shell, at any rate of the spines that exhibit a series of superficial lamellæ, which appear to have been recently deposited, and which are quite independent of the regular horizontal lamellæ of the shell (Fig. 18).

I do not think that the internal character of the valves in *Ephippodonta* and *Chlamydoconcha* is due to any phylogenetic connection between the two, as the other points in their anatomy differ so widely, but rather that this feature has arisen independently in both. On the other hand the partial enclosure of the shells of *Galeomma* and *Scintilla* in all probability represents a stage in the evolution of the condition seen in *Ephippodonta*, since these three genera are undoubtedly closely related to one another.

The Labial Palps:—Two pairs of labial palps are present as in *Galeomma*; the outer or anterior pair are small triangular structures, the free angle being roughly 90° (Figs. 2 and 8, *lp*^{1}, *lp*^{2}). They are situated on either side of the mouth, their bases being attached between anterior adductor and the pedal protractor, slightly overlapping both. The posterior pair are very small and completely hidden under the larger anterior pair. The anterior free borders of the two mantle folds are slightly inturned (retracted) and developed in such a way as to roughly suggest an anterior pair of palps; these probably form the funnel-like structure that Tate speaks of in the live specimen.

The Mantle cavity:—The branchial (infra-branchial) chamber (Figs. 12 to 15, *b.c.*), which is almost filled up in the contracted state by the gills and body, is widely open below for about three-quarters of its length. The posterior fourth of this cavity is closed below by the fusion of the ventral edges of the mantle and ends blindly in two cæcal diverticula (Fig. 15, *b.c.*), which are separated from the supra-branchial chamber by the union of the two outer gill-lamellæ and by a horizontal muscular ingrowth of the mantle. During life this cavity must be widely open, so much so that the gills and the body must project freely.

The supra-branchial (anal) chamber (Figs. 12 to 15, *sp.b.c.*) receives the opening of the rectum, also the paired genital and excretory orifices, it is single behind and communicates with the exterior by the small exhalent siphon; anteriorly the single chamber becomes divided into three by the union of the inner lamella of the outer and the outer lamella of the inner gill (point of origin of the gill) with the body wall. Still further forward we find the middle portion of this cavity becoming again sub-divided by the intervention of the posterior

[1] Jeffreys, Brit. Conch. v., p. 176, 1869.
[2] Sur le genre *Scintilla*, Par G. P. Deshayes, Proc. Zool. Soc. 1855, p. 171.

portion of the visceral mass. So that we now find four sub-divisions of the supra-branchial chamber. The two innermost ones communicate with the branchial chamber by a slit situated between the gill and the posterior portion of the visceral mass (Figs. 12 to 15, *sp.b.c.*)

The Foot is very large, and Tate describes it as "somewhat disc-shaped" in the contracted state;[1] however, this is not apparent in my specimens, the most striking feature being its sub-division into three lobes visible both from below and from the side, the anterior or free portion being roughly pointed and tongue-shaped. The two posterior lobes which are more closely united to the body contain the byssal gland; viewed from below (Fig. 1, *b.*) they present an elongated groove which widens out in the posterior lobe, and from which the byssus protrudes. Tate makes no mention of this byssal groove, although it is a most conspicuous feature. The byssal gland is well developed and situated in the middle lobe of the foot; the groove, which extends for some depth into the foot and giving off a few irregular diverticula, suddenly divides into two, the two halves curving gracefully outwards and receiving a dorsal series of curved ducts, so that one might roughly compare it with a palm-tree (Figs. 3 and 10, *b.g.*). Both *Galeomma* and *Scintilla* are byssiferous.

The Respiratory and Circulatory systems:—The gills of *Ephippodonta* are those of a typical Eulammellibranch, and consist of two pairs of lamellæ; the internal ones extending slightly in front of the external ones (Figs. 4 and 5, g^1 and g^2), which latter overlap the former behind and fuse with one another in the middle line in this region. In the contracted state (Figs. 11 and 12) each lamella is bent so that its free edge forms an angle with the main portion, the flexure tending towards the median line.

The histology of the gill filaments is not easy to make out, as the latter are very much caked together, but it does not appear to differ in any way from that of the more typical forms (Fig. 17).

The heart is small and difficult to make out; it consists of a pair of auricles and a small muscular ventricle, the latter being perforated by the rectum (Fig. 12, *v.au.*). The further details of the blood vessels and other circulatory organs I have been unable to determine with any precision. The pericardium (*p.*) is large and surrounds the heart and rectum. The kidneys (Fig. 13, *k.*) are situated just dorsal to the visceral (olfactory? or parieto-splanchnic) ganglia, and appear to be perforated by the posterior pedal retractors. They consist of well marked coiled tubular, glandular segments, and large receptive bladders which communicate with one another across the middle line and with the supra-branchial chamber on either side of the body close to the opening of the genital ducts; the reno-pericardial aperture I have not seen.

The Genital Glands.—The sexes are distinct, but I have only examined males, as all four of my specimens belonged to that sex. The testes are diffuse, tubular glands extending forwards as far as the stomach, and ramnifying amongst the intestines and liver and back to the kidneys

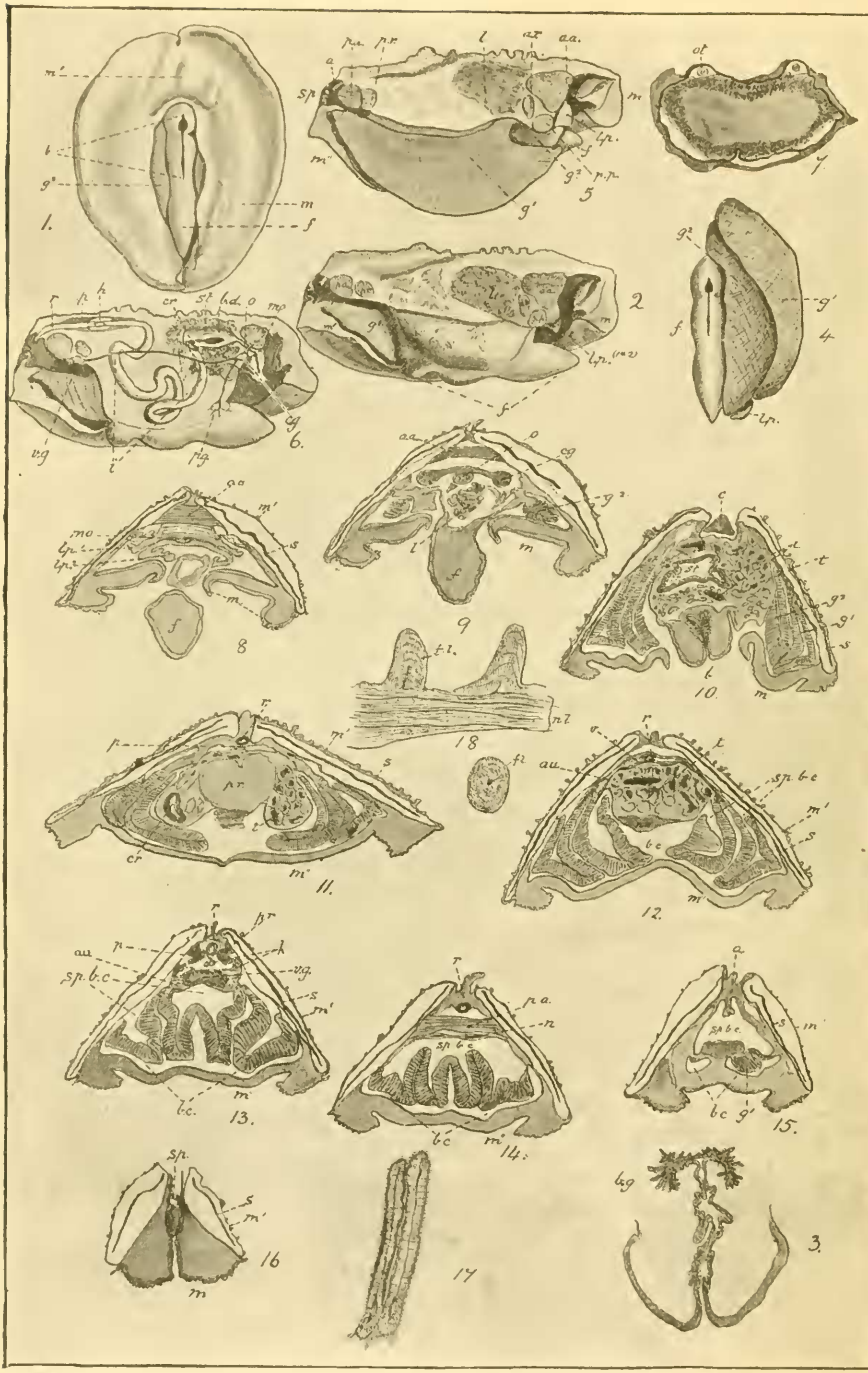
[1] In his second paper Tate corrects this error.

(Figs. 10 to 12, *t.*), in the region of which they open into the supra-branchial chamber by well marked ciliated ducts. The animals were evidently killed just about the breeding season, as they are full of ripe spermatozoa, some of which had been discharged from the duct. Besides the ripe spermatozoa the tubules are full of yellowish globules, which are probably nutritive in function and correspond with the oil globules met with in the testes of other animals.

The Alimentary Canal.—The mouth (Figs. 6 and 8, *mo.*) opens between the four labial palps, the union of the two anterior and two posterior palps forming a kind of upper and lower lip; passing from the mouth is a well marked ciliated œsophagus, which in turn communicates with a large stomach (Figs. 6 and 10, *st.*). The digestive gland (Figs. 2, 5 and 9, *l.*) opens into the stomach through two large bile ducts (right and left); this gland is a very large one, and, besides ramifying round the œsophagus and stomach, extends back for a considerable distance amongst the coils of the intestine. The posterior portion of the stomach is elongated horizontally (Fig. 10, *st.*), and the cilia reappear on its lining cells and indeed become extremely long on the ventral surface; they were wanting in its anterior region owing to the presence of a thick protective secretion which covers the cells and projects freely into the cavity (this is the 'flèche tricuspid' of Poli). From the postero-ventral region of the stomach two tubes arise; the larger (Figs. 6, 10 and 11, *cr.*) on the left is a conspicuously ciliated tube, it runs downwards and backwards keeping close to the surface of the body and finally ends blindly close to the foot; this cæcum from its position obviously represents the crystalline-style sac, but in the specimens examined it contained no secretion. The second opening out of the stomach is on the right side and is much smaller; it leads into a tube which, owing to the fact that in the specimen before us it is empty, is of small calibre, although in some specimens it was enormously distended; this is the first coil of the intestine (Figs. 6 and 10, *i.*). The intestine, which is situated entirely on the right side of the body, is only of moderate length and very simple; it runs obliquely downwards and backwards, and, after making a slight twist or two, turns sharply forwards and ascends to near the hinge, where it again bends abruptly backwards and runs to the anus as the rectum, which is distinctly muscular and contracted and consequently appears of small size.

The Nervous System (Fig. 6) is very prominent, the cerebral, pedal and visceral (pariето-splanchnic) ganglia being all of very large size; these ganglia and their commissures have the typical relations as exemplified in *Anodon*. A pair of minute otocysts (statocysts, Fig. 7) were present on the upper side of either pedal ganglion; each contained a single large round otolith, and only occupied one section of about $\frac{1}{70}$ mm. in thickness. These were the only undoubted sense organs that I was able to identify.

All the above facts which I have pointed out tend to confirm Prof. Tate's statement as to the affinities of this genus with *Galeomma* and *Scintilla*, and if we further compare his description of the method of progression of this form with that of *Galeomma*, we shall see that in



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